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How effectively low carbon society development models contribute to climate change mitigation and adaptation action plans in Asia

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ABSTRACT

Backcasting is not a new concept for scientists dealing with carbon mitigation or climate change mitigation issues around the world, but could be an innovative idea for public, local, and national policy planners as they are so far only familiar with forecast scenarios for different issues and sectors. Defining a roadmap to achieving low carbon targets and explaining these targets in quantitative form as much as possible is known as backcasting. Plenty of computer-based quantitative models and tools are used to outline low carbon society scenarios in the Asia-Pacific region and implementations of such models are underway. This paper spotlights these quantitative models and tools which are used to achieve backcasting benchmarks. These models are critically reviewed for their functioning and real possibilities on ground levels and suggestions have been made to improve practical implementation in developing Asia. The study found that all these models are highly acceptable and applicable in Asian countries but actual applications are rare, with Japan as the leading country in implementing such applications, followed by Malaysia. Estimation of CO_2 sinks, open availability, and energy service demands (built-in option) are major weaknesses of the models. We also concluded that these computer-based quantitative models are helpful for almost all of the countries of the Asia-Pacific region facing such issues as data limitation, fewer resources, and lack of government participation.

Contents

1. Introduction

The keywords such as materialization, carbon mitigation, low carbon societies, sustainable consumption and production, and climate change mitigation and adaptation, all represent aims to reduce the burden on the planet through sustainable development. To present, plenty of articles, research papers, booklets, workshops, and symposiums have been carried out to identify the impacts, changes, causes, effects of, as well as tackle solutions to climate change issues. In the Asia-Pacific region, the term low carbon society is very popular, especially among emerging economies like China, Malaysia, and India. Japan is also eager to achieve its 2050 goal to reduce carbon emissions by half compared to the level in 1990 [1,2]. Japan is leading in emissions reduction and real

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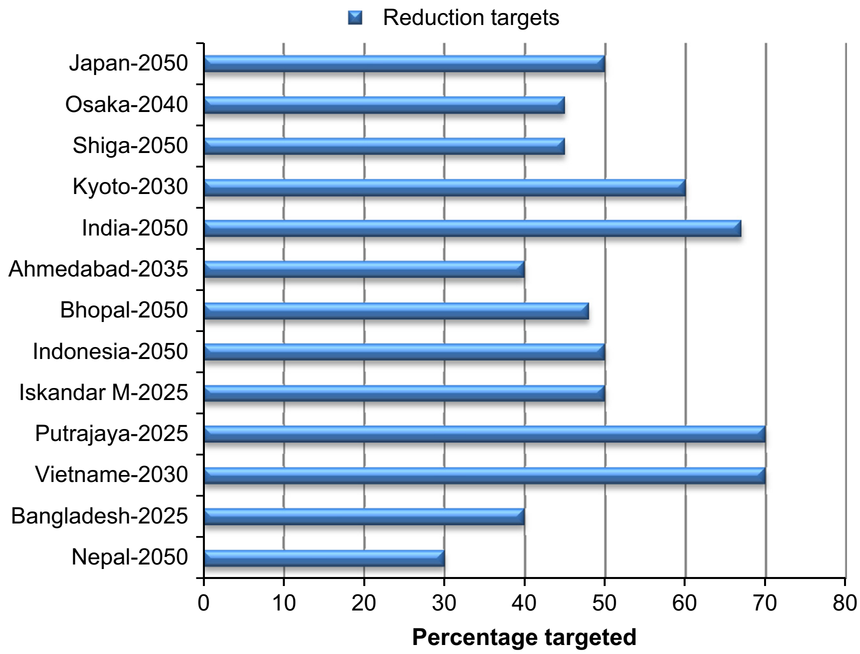


Fig. 1. Carbon reduction targets of different Asian countries and cities till 2050. Data compiled by authors on the basis of [13–25].

implementation of the emission reduction targets. Most of its cities like Kyoto, Shiga, and Osaka have started to work in line with set targets and real application on ground levels are becoming obvious with the passage of time. Fig. 1 shows the reduction targets set by different countries and cities of Asia.

For an inexperienced or young researcher in this field, it would be helpful and interesting to understand what is meant by low carbon scenario development, or low carbon societies. The answer is low carbon societies aim at lowering their GHG emissions and, in particular, carbon emissions without effecting their economic growth at significant levels. This further includes the minimal use of intensive energy while shifting towards a resource efficient society that incorporates renewable energy concepts and behavioral changes in societal aspects such as transport modes, among others. Categorically, low carbon societies will move towards a lower contribution to the global warming phenomenon, helping to provide a sustainable earth for the next generation [3–6].

Since 1997, most countries have signed the Kyoto Protocol, but many of them have questioned why developing countries must set low carbon emission targets and move toward low carbon and resource efficient societies, as their priorities are far different from those of previously developed countries. According to Fujino and Asayama, 2011 [7], mean economic growth of large Asian countries ranges between 3.4% and 4.4% from 2005 to 2050, as per annual estimations, portraying the annual growth rate as higher than the global economic growth rate of 2.3–3.2%. Likewise, the Asia-Pacific region will be responsible for almost half of global GHG emissions in 2050, which is a vulnerable situation [8]. Similarly, sea levels will rise to 1 m by 2100, meaning 20% of the islands would diminish from the Earth by 2100 [9]. Thus there is need for leap-frog development, the identification of the sustainable economic path with the least effect on the nature without damaging the carrying capacity of the globe. Leap-frog development for low carbon growth can involve different aspects of society to achieve low carbon growth rates; for example urbanization, institutions and technology, and policy options, to name a few. Thus, developing countries need to envisage low carbon issues to mitigate climate change impacts. Fig. 2 shows leap-frog development ensuring a low carbon society with the backcasting idea.

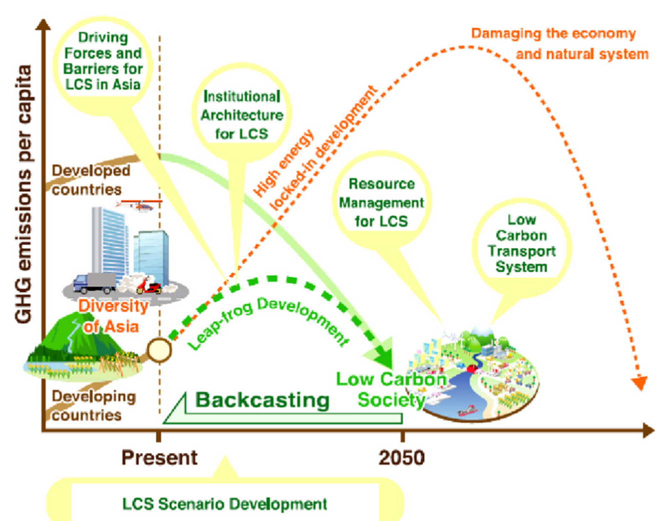


Fig. 2. Leap-frog development approach for low carbon societies of Asia [7].

All these conditions and situations put a great emphasis on lowering emissions in the respective countries by using leap-frog development methods and by considering climate change mitigation and adaptation action plans in the making of national policies [10–12]. Hence, the low carbon society approach has been modernized by the National Institute for Environmental Studies, Japan; Kyoto University, Japan; and the Institute for Global Environmental Strategies, Japan through joint ventures among the most vulnerable and potential countries of Asia, such as China, India, Vietnam, Malaysia, and Thailand. These institutes have introduced a few Asia-specific integrated models to estimate the current and future emissions of a particular country/city and then re-estimate the emissions by including low carbon consumption patterns, technologies, policies, and living standards. This article reviews all these low carbon computer-based and quantitative policy models/tools and provides a critical discussion on the practical implementation of these models, presenting the pros and cons of the models

along with weaknesses of the models/tools in the Asia-Pacific region.

The article has been divided into 7 main parts; starting from introduction, Section 2 explains availability and suitability of models; Section 3 includes usage of these models in the literature; Section 4 describes ground implementations and applications of the models; Section 5 comprises gaps and areas to improve; Section 6 presents the pros and cons of the models and tools; lastly, concluding remarks are contained in Section 7.

2. Availability and suitability of models and tools

There are plenty of tools, models, and approaches being implemented in societies at present. A society can adopt a best approach according to its socio-economic characteristics, limitation of information available, and the targets it wants to set. What is most important, however, in the creation and real implementation of such scenarios is that the scenario must be true representative of the country, with major sectors/areas highlighted properly and so that the scenario is applicable in real practice as well. One should keep in mind that the inclusion of these low carbon scenario created policies keeps the potential for local or national governments to implement such policies aiming at mitigating climate change impacts.

In this regard, initial steps were taken by the joint venture of the National Institute for Environmental Studies (NIES), Japan; Kyoto University, Japan; and Institute for Global Environmental Strategies (IGES), Japan. The program was originally launched by NIES in second half of 2000 on the name of "Asia Low Carbon Societies Research Project", being still under progress with later collaborations made. They introduced a few computer-based quantitative models by which each country could estimate their current GHG emissions, future scenarios, and how to reduce carbon emissions by including various countermeasures. Salient models among them are the Asia-Pacific Integrated Model (AIM) that is further extended to the AIM enduse model (launched in 2000), the AIM energy snapshot tool (launched in 2003), and the Extended snapshot tool (ExSS) (launched in 2006), [8,15]. On the contrary, another famous model, the called-as Market Allocation (MARKAL) model, has been used abundantly in different studies [25–28] in Asia and around the world. MARKAL is not from NIES, but it has been developed by Energy Technology Systems Analysis Program of International Energy Agency (IEA) and is equally famous and applicable all over the world [29,30]. Likewise, the French model developed by ADEME, named as Bilan Carbone®, has been widely used in France and Europe and is now getting popularity in the Asia-Pacific region as well, though few studies have used it as of yet. However, there are a few unpublished master and Ph.D. theses from Asian Institute of Technology, Thailand that have used this model for various countries like India, Thailand, Vietnam, and Pakistan [31–33]. The prototypes are also being run on different countries by the Action towards resource-efficient and low carbon cities in Asia team [34], but results have yet to be published so far. This is the latest model being implemented in the Asian countries for the very first time, unlike AIM and MARKAL models/tools, which have been tested widely in Asia.

Having said that, the AIM enduse and AIM energy snapshot tools have been relatively unused in studies when compared to other tools, with only very rare examples published in the international literature. On the other hand, the Extended Snapshot tool (ExSS) has been extensively used by Asian countries to set low carbon emission reduction targets (for example see [13–25]).This tool has been used to set GHG emissions and reduction targets by different countries such as Japan, Malaysia, Thailand, Vietnam, Bangladesh, Indonesia, China, and India, among many others. Thus, ExSS has been carried out by almost half of Asian countries, excepting a few from Central and West Asia. The common characteristics among these models include, that they are all Analytical Hierarchy Process (AHP) based models and all are MS-Excel spread sheet calculations to help in outlining carbon footprints, allowing for policy design according to both current and future situations for meeting the targets committed to under the Kyoto Protocol. This also further confirms that AHP models help in multi-criteria decision making processes and are more abundantly used in Asia than anywhere else in the World (Fig. 3). Indeed, these are very helpful and comprehensive models to set action plans and achieve the set goals to mitigate climate change and move towards adaptation. It is for these reasons that these models are justified selections for this study.

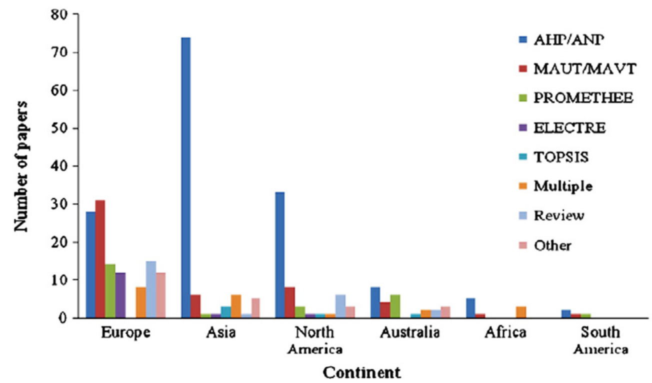


Fig. 3. AHP modeling trend in Asia and other regions of the World [35].

3. Usage of these models/tools available in the literature

The story does not end here as using a model or tool and simply showing results is not a success story; to calculate emission levels and future scenarios is not enough for a country to plan actions against climate change. Though this could be applicable to research students' projects or assistants working on specific tasks, it is not sufficient for decision makers. Estimation is the beginning of knowledge for implementing this information through policies into the national and local plans. Then through the support and interest of the government, research institutes, and practitioners, these policies should be implemented on ground levels to bring real change and subsequently adapt the action. Almost all of the countries in Asia are aware of the threats of climate change and vulnerability to the different threats. Table 1 shows the different threats related to climate change reported by the United Nations Development Program (UNDP). According to UNDP, 15 Asian developing countries out of 26 are under the threats of storm, flood, drought, and 1 m coastal rise [36]. Thus, there is need to take timely and appropriate actions, especially for countries which are vulnerable to climate change impacts.

Low carbon scenario development (LCS) in Asia is a bold step to cope with climate change, but estimation is not the only step to perform; adaptation of actions and policies at national, city, and household levels is direly needed. Capacity building is also an important element for enhancing the interest and wining the confidence of communities, and in so doing achieving significant results. Likewise, Asia is supposed to cut half of its emissions in the future: "Halving global GHG emissions by 2050 from the 1990 levels will be achievable, but it is not easy; actions in Asia regions are essential to achieve this reduction target" [7]. Fig. 4 shows the potential of mitigation options for Asia, particularly to achieve a 50% reduction target in global emissions. Having said that, most of

Table 1
Six climate threats to different countries of the world [37].

Drought	Flood	Storm	Coastal 1 m	Agriculture
Malawi	Bangladesh	Philippines	All low-lying Island states	Sudan
Ethiopia	China	Bangladesh	Vietnam	Senegal
Zimbabwe	India	Madagascar	Egypt	Zimbabwe
India	Cambodia	Vietnam	Tunisia	Mali
Mozambique	Mozambique	Moldova	Indonesia	Zambia
Niger	Laos	Mongolia	Mauritania	Morocco
Mauritania	Pakistan	Haiti	China	Niger
Eritrea	Sri Lanka	Samoa	Mexico	India
Sudan	Thailand	Tonga	Myanmar	Malawi
Chad	Vietnam	China	Bangladesh	Algeria
Kenya	Benin	Honduras	Senegal	Ethiopia
Iran	Rwanda	Fiji	Libya	Pakistan

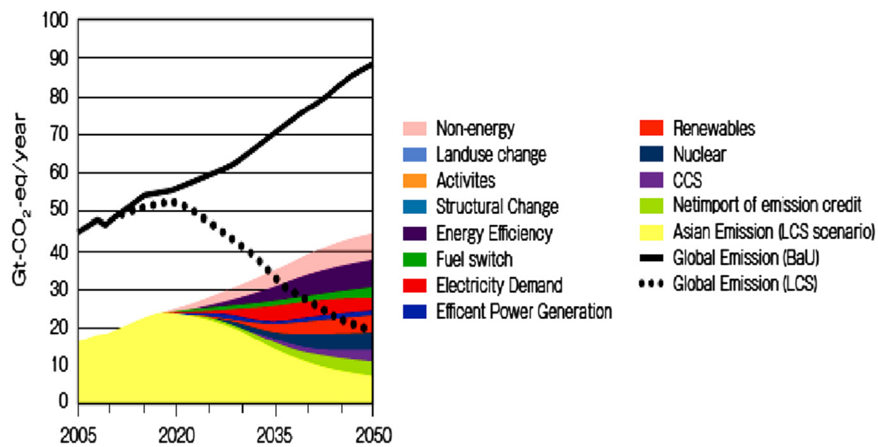


Fig. 4. 50% Reduction in GHGs of total global emissions by Asian countries by 2050 [7].

the cities of Japan have set their own targets as explained in Fig. 1, although it is not the complete list of local municipalities or cities. According to Gomi et al. [15], there are 83 municipalities that set targets for "Environmental Model Cities" and they are on their way to achieve these targets by any means. Real applications can be observed in the Kyoto, Osaka, and Kitakyushu cities.

Similarly, Putrajaya city of Malaysia has the vision of "Putrajaya Green City 2025" and they set to achieve 45% GHG emissions reductions by 2025 as compared to the level of 2005 [21]. Likewise, Cyberjaya city of Malaysia is nearly identical to Putrajaya city, having similar targets and setting a vision for 50% reduction from each sector as of Putrajaya [22]. Another city of Malaysia, called-as Iskandar, Malaysia, has been set to reduce its carbon emissions by 50% by 2025 as compared to the level of 2005, a goal which sounds quite challenging [37]. One of the largest countries of Asia, India, has also taken few steps in this regard to reduce their ecological footprint and set goals to fight against climate change impacts. A few cities of India such as Ahmedabad and Bhopal have set their own goals individually, but of course with the collaboration of NIES and related parties, to lower their emissions and preserve their resources for the next generation. Generally, India aims to achieve a 67% reduction in CO_2 emissions by 2050 as compared to the level of 2005.

China is not behind in this race. At the G8 summit of 2008, China committed to reduce its CO_2 emissions by 50% by 2050 as compared to the level of 2005 [38–40]. Plenty of literature is available on the low carbon reduction targets, policies, and actions in various sectors of the economy and judged from different angles [38,41,42]. However, China is a very important region whose population growth presents a constant challenge to setting targets and meeting them on time without effecting the pace of economic growth.

4. Ground implementations and applications of the models

Designing policies, setting targets, and using computer-based models for estimation is not the ultimate purpose of today's research. The necessity of the current era is more complex and demanding than ever before. We need to take action rather than know and plan only. Usage of these models is extensive in Asian countries, but we try to investigate to what extent these emission reduction targets have been accepted by the national/local governments and what is the prospect of their implementation. In this regard, there are not many examples in existence so far as compared to the quantification number of cities and countries conducted in collaboration with the LCS research project team.

Starting from Japan, the Kyoto city government has adapted various actions recommended by the "Research Team of Sustainable Society Kyoto" [20]. They conducted quantitative estimations using the ExSS tool in 2009 and proposed six main actions to mitigate GHG emissions in the city. The city government has not only included these action plans into the policy agenda, but also started to implement them as well. They targeted to achieve a 40% CO_2 emissions reduction by 2030 as compared to the level in 1990. Another city of Japan, Kitakyushu, is excelling in environmental management aspects. They have designed policies, set targets, and started to implement immediately so that the reduction timeframe should not be extended. Kitakyushu is a "zero emissions" city as of 2012; all waste is recycled and reused in the "Eco-town" located within the city [43]. The Kitakyushu city government is committed to reducing GHG emissions to 50% by 2050 as compared to the level of 2005. The project cost is 16.3 billion yen in total and out of that 1.37 billion yen is contributed by the local government, the rest from national government. The city adapted the smart meters,

renewable energy use, recycling, and clean manufacturing actions and policies to develop a low carbon society.

Similarly, Putrajaya city of Malaysia has the vision of “Putrajaya Green City 2025” and through this they set to achieve a 45% GHG emissions reduction by 2025 as compared to the level of 2005. The city planners are mainly working on three visions, i.e. low-carbon Putrajaya, a target to reduce carbon emissions by 60%; cooler Putrajaya, a target to reduce temperature by 2 °C; and 3 R Putrajaya, a target they want to reduce final solid waste disposal by 50% and GHG emissions from waste by 50% as well [21]. For this purpose, the city has already been in action, designing buildings, roads, infrastructure, and transport system in a way that ultimately helps in reducing GHG emissions and really leads toward a model city. They are committed to achieve the target by 2025. Same is the case for Iskandar, Malaysia, with targets set, action plans accepted by the local government, and implementation underway since 2011 in order to achieve the desired emission levels and sustainability within the specified time period.

Thailand's government has also considered the low carbon society plans recently and decided to include them into the national policy agenda of 2012. The decision to include the LCS agenda to drive the low carbon markets is expected to be announced in COP18 by the Thai government [44]. There are three municipalities of Thailand, Nonthaburi, Khonkhen, and Klang municipalities, which are working at the local level and are committed to go green by helping themselves. They are mainly dealing with solid waste management and are committed to lowering their GHG emissions through waste minimization and recycling for renewable energy. Hence, Thailand will be the third country in Asia to implement low carbon society concepts in reality, after Japan and Malaysia.

Surabaya city is the only city of Indonesia to achieve their emissions reduction goal through solid waste management. The recycling of solid waste was initiated with the collaboration of IGES, Japan in 2004. Within 5–6 years, the city officials and community members have achieved CO_2 emissions reductions of 4000 t in 2007, 7000 t in 2008 and are expected to reach as low as 12,000 t in 2012 [45]. This reduction in carbon emissions lead to the earning of almost USD 35,000 in 2008 and could be USD 60,000 in 2012, according to the carbon credit market rates. This is not only an environmental achievement, but also financially impressive. IGES is planning to replicate this case in other cities and countries of Asia in the near future.

5. Pros and cons of the models and tools

Of course, no method is perfect in the world of science and so is the case for these models. Quantitative models help significantly in estimation of GHG emissions, presenting at least a close picture which is quite helpful in understanding the situation and then planning policies accordingly [46–48]. If an exact and perfect estimation was desired, it would require hanging GHG emissions meters on the neck of every cow, setting meters on the silencer of every car, bike, and bus and on the chimney of every factory, which is not practical and probably not even possible in this era. Therefore, computer-based models were generated and people were trained according to the needs of the regions, countries, and local situations. Now these models and tools have become a permanent source of emissions knowledge for particular areas and most of governments, authorities, and researchers rely on such tools. This is perfectly normal thing to do in the current situation because we are left with no other option, as explained above, and these are widely trusted methods. While these models are broadly accepted, according to our analysis and observation there are a few advantages and disadvantages of these models which make them different from each other and significant as well. We have put them together in an analysis modus to provide ease for researchers who feel difficulty in choosing such models according to their data limitations and socio-economic situations. Table 2 explains the different types of models and their strengths and weaknesses.

It is obvious from the table that none of the models have all options and facilities in full as compared to each other. These are top-used models within the Asia region and in other countries as well, according to the literature published and collected so far. The major obstacle which is found in general is embedded service demand estimation. For these models, service demand has to be estimated separately and then that data must be imported to the spread sheet and entered manually. This is a commonly missing option in the majority of models except for one or two models. Likewise, the land use change factor is totally missing in all of these models/tools right from the beginning. Land use is a very important element to consider when talking about CO_2 emissions [48–50]. Land use analysis could be an option to estimate the CO_2 sinks and then net emissions could be extracted at the end, with the resulting emissions being final CO_2 emissions for analysis and examination.

Another distinctive problem which is mainly faced by the young researcher is the free availability of these models. Among all of these models, only the AIM energy snapshot and enduse models are freely available, though they were not a few years ago, having only recently been opened to the common researcher as well. These free models are available here (http://www-iam.nies.go.jp/aim/infomation.htm). It is quite embarrassing that many researchers are willing to do work in this field, but many choose not to do only to the unavailability of models/tools. This is quite a serious issue which is being faced by young researchers and particularly researchers from developing countries. The availability and visibility of such models should be provided at easy steps or at nominal prices and conditions if possible.

Table 2
Diverse pros and cons of the models and tools.

Specifications	AIM enduse	AIM energy snapshot	ExSS	Bilan Carbone	MARKAL
CO_2 emissions targets	x	x	x	x	x
Country-specific EF[a]			x	x	x
Data requirements	Medium	Medium	High	High	High
Factor analysis		x			
Land use change/CO_2 sink estimations					
Tailor-made estimations			x	x	x
Cost estimation			x		x
Service demand built-in					
Free availability	x	x			
Tax/subsidy regulation classification	x				
Emissions from waste, food, future packaging				x	

[a] Emission factors.

There are other issues related to the cost estimations of CO_2 reduction targets, specific emission reduction targets, data availability and limitations, factor/decomposition analysis, etc., which are part of these models' weaknesses. Conclusively, major weaknesses of these models are land use change estimation, factor analysis, cost estimations, and energy service demand options within the models.

6. Gaps and areas to improve

There could be significant changes within these existing models and tools. There is a necessity to improve these methods and models rather than establish new programs. Every system contains strengths and weaknesses but a few among them need proper attention to work things in a better way. There is huge potential for improvement within these models and gaps could be filled in a very possible way. Talking about the AIM models, being largest category and broadly accepted models in the Asia-Pacific region, these models are many but none fulfill all the requirements in one package. For example, AIM enduse model provides a tax/subsidy regulation classification option but in the meantime there is no choice of land use/CO_2 sinks estimations. Likewise, Bilan Carbone® is particularly exceptional in helping the estimation of emissions from waste, food, and future packaging, but, on the other hand, it is lacking in factor/decomposition analysis, built-in service demand, and tax/subsidy options. Thus all of these computer-based quantitative models are lacking in a few major and important areas which should be improved timely.

According to observations and based on personal experiences from different researchers and practitioners, it is found that ExSS, MARKAL, and Bilan Carbone have high potential to envisage changes because their acceptance rate is higher in Asia among the researcher community. (Fig. 5) shows the popularity graph of these frequently used models and it is obvious to analyze that the models with more options are openly acceptable to the users as compared to those with limited options. Another specific concern in the usage of these models and tools is the country selection. The low carbon society (LCS) project team has been intensively involved in Southeast Asia and South Asia, while Central and West Asia have been ignored. There is no such application or story available from Central and West Asian countries like Iran, Pakistan, Mongolia, and from the Pacific Islands. These countries have significant importance in the region and problems cannot be solved without involving them. The LCS project team should also consider these countries in order to motivate them and support them in developing reduction targets so that equal environmental standards and legislations can be followed in the region to meet the agenda for 2050.

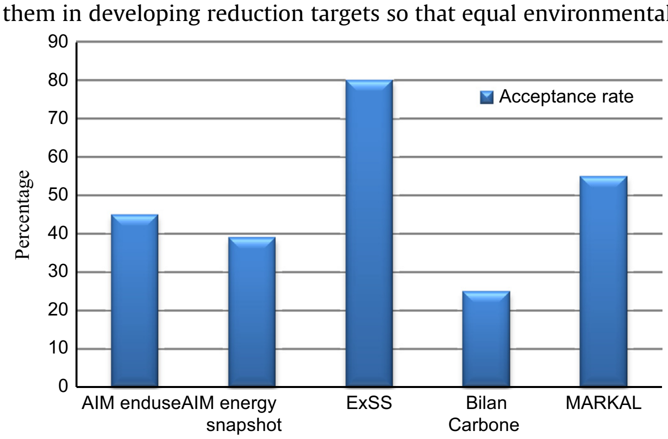


Fig. 5. Usage frequency graph of selected models/tools in Asian countries.
Source: The data for this graph collected from the previous literature published in Web of Science database, using simple frequency approach and compiled by authors.

7. Concluding remarks

The low carbon society development plan is gaining popularity among developed and developing countries of Asia such as Japan, China, and Malaysia. Most of the countries have already set their low carbon emission targets for the coming years. Few of them have started to implement the action plans in reality and some, such as Thailand, India, and Vietnam, are at the stage of policy inclusion into national and local governments. Keeping in view all these factors, the base to develop and implement such plans were started through computer-based quantitative modeling, which further became a base for designing policies and action plans for local as well as national governments. These models and tools, which are implemented and extensively used at present in the Asia-Pacific region, were critically reviewed, their different success stories, pros and cons were traced, and knowledge gaps that need to be filled were suggested.

It is found that despite the limitations and lowered availability of different options, these models are used extensively in Asian countries and their results are used as bases with high reliability rates. It is found that these models have significant margins for improvement in a few important areas. If mentioned gaps are filled in these models, they could serve with more diversity and could be replicated into more than half of Asian countries. It is highly emphasized that these models/tools should be made openly available to the researchers from developing countries with less resources and a greater focus should be placed on the rest of the Asian regions, such as Central and West Asia and Pacific Islands. The LCS research project team should increase its collaboration circle and motivate the rest of the countries to estimate their emissions and craft their action plans accordingly. Last but not least, through the analysis it is realized that the effort put forth by NIES, Kyoto university researchers, and IGES, Japan is worth mentioning here. Being pioneers in Asia to start the low carbon society research project, they have set standards by introducing such models which are very helpful for any country to make quantitative estimations of their GHG emissions and then look forward to action plans. Their effort is greatly appreciated and through this analysis we hope the gaps mentioned in this article would be considered by them for forthcoming models/tools so that a complete package for low carbon society development scenarios may be available.

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References

[1] van Vliet N, Mertz O, Heinimann A, Langanke T, Pascual U, Schmook B, et al. Trends, drivers and impacts of changes in swidden cultivation in tropical forest–agriculture frontiers: a global assessment. Global Environmental Change 2012;22(2):418–29.
[2] Avishek K, Yu X, Liu J. Ecosystem management in Asia Pacific: bridging science–policy gap. Environmental Development 2012;3:77–90.
[3] Welch A, Gaines S, Marjoram T, Fonseca L. Climate engineering: the way forward? Environmental Development 2012;2:57–72.
[4] Mol APJ. Carbon flows, financial markets and climate change mitigation. Environmental Development 2012;1(1):10–24.

[5] Keleş S, Bilgen S. Renewable energy sources in Turkey for climate change mitigation and energy sustainability. Renewable and Sustainable Energy Reviews 2012;16(7):5199–206.
[6] Karakosta C, Doukas H, Psarras J. Technology transfer through climate change: setting a sustainable energy pattern. Renewable and Sustainable Energy Reviews 2010;14(6):1546–57.
[7] Fujino J, Asayama Y. Asian low carbon societies (LCS) research project 2050. Tsukuba, Ibaraki, 305-8506, Japan: National Institute for Environmental Studies; 2011.
[8] NIES. Asia-Pacific Integrated Model team. National Institute for Environmental Studies; 2012 ⟨http://www-iam.nies.go.jp/aim/index.htm⟩ [accessed 05.06.12].
[9] IPCC. IPCC guidelines for national greenhouse gas inventories. Eggleston HS, Buendia L, Miwa K, Ngara T, Tanabe K, editors. Prepared by the National Greenhouse Gas Inventories Program. IGES: Japan; 2006.
[10] James P. Overcoming barriers to low carbon dwellings: The need for innovative models of finance and service-provision. Environmental Development 2012;2:6–17.
[11] Cohen T. Can participatory emissions budgeting help local authorities to tackle climate change? Environmental Development 2012;2:18–35.
[12] Acquaye AA, Sherwen T, Genovese A, Kuylenstierna J, Lenny Koh S, McQueen-Mason S. Biofuels and their potential to aid the UK towards achieving emissions reduction policy targets. Renewable and Sustainable Energy Reviews 2012;16(7):5414–22.
[13] Deshpande A, Kapshe M. Low carbon society scenario Bhopal 2035. Bhopal 462051, India: Maulana Azad National Institute of Technology; 2010.
[14] Dewi RG, Kobashi T, Gomi K, Yuzuru M, Ehara T, Kainuma M, et al. Indonesia low carbon vision of 2050 in energy sector. Indonesia: Institut Teknologi Bandung (ITB); 2010.
[15] Gomi K, Shimada K, Yuzuru M. A low-carbon scenario creation method for a local-scale economy and its application in Kyoto city. Energy Policy 2010;38:4783–96.
[16] Ho CS, Yuzuru M, Simson J, Gomi K. Low carbon urban development strategy in Malaysia—the case of Iskandar Malaysia development corridor. Habitat International 2013;37:43–51 http://dx.doi.org/10.1016/j.habitatint.2011.12.018.
[17] Hoa NT, Gomi K, Yuzuru M, Tu TT, Fujino J, Kainuma Met al. Preliminary study on sustainable low-carbon development towards 2030 in Vietnam. Sponsored by AIM, NIES, Japan. Japan, 615-8540: Graduate School of Engineering, Kyoto University; 2010.
[18] Jilani T, Gomi K, Yuzuru M. Low carbon society development towards 2025 in Bangladesh. Kyoto 615-8540, Japan: Department of Urban and Environmental Engineering, Kyoto University; 2011.
[19] Limmeechokchai B, Chungpaibulpatana S, Nitisoravut R, Winyuchakrit P, Pattanapongchai A. Thailand's low-carbon society vision 2030. Thailand: Sirindhorn International Institute of Technology, Thammasat University; 2011.
[20] Naito M. A roadmap toward low carbon Kyoto. Kyoto, Japan: Research Team of Sustainable Society; 2009.
[21] Siong HC, Abidin AZ, Hashim OB, Termizi AA, Yuzuru M, Fujiwara T, et al. Putrajaya green city 2025: baseline and preliminary study. Malaysia: Universiti Technologi Malaysia (team leader); 2011.
[22] Siong HC, Neo WH, Yuzuru M, Fujiwara T, Kurata G, Fujino J. Cyberjaya digital green city 2025; feasibility study. Malaysia: Universiti Technologi Malaysia; 2011.
[23] Shukla PR, Pangotra P, Bazaz AB, Agarwal P, Agarwal N. Ahmedabad low carbon society vision 2035. Ahmedabad, India: Indian Institute of Management; 2009.
[24] Shukla PR, Agarwal P, Bazaz AB, Agarwal N. India low carbon society vision 2050. Ahmedabad, India: Indian Institute of Management; 2009.
[25] Shrestha RM, Rajbhandari S. Energy and environmental implications of carbon emission reduction targets: case of Kathmandu Valley, Nepal. Energy Policy 2010;38:4818–27.
[26] Kannan R. The development and application of a temporal MARKAL energy system model using flexible time slicing. Applied Energy 2011;88(6):2261–72.
[27] Shrestha RM, Shakya SR. Benefits of low carbon development in a developing country: case of Nepal. Energy Economics 2012;34(3):S503–12 http://dx.doi.org/10.1016/jeneco.2012.03.014.
[28] Shrestha RM, Pradhan S. Co-benefits of CO_2 emission reduction in a developing country. Energy Policy 2010;38:2586–97.
[29] Motoki Y, Kosaka H. Local energy planning for Japanese municipalities. Kanagawa 252-8520, Japan: Graduate School of Media and Governance, Keio University; 2011.
[30] IEA. Energy Technology Systems Analysis Program (ETSAP). Ireland: International Energy Agency, Energy Policy and Modelling Group, School of Engineering, University College Cork; 2012.
[31] Ali G. Low Carbon society development using multidisciplinary approach in a metropolitan city of Pakistan. Thailand: Asian Institute of Technology; 2012 [Unpublished Ph.D. dissertation].
[32] Kolsepatil N. Estimation of carbon footprint for an Indian diesel engine manufacturing industry. Thailand: Asian Institute of Technology; 2011 [Unpublished master thesis].
[33] Lamkitcha C. Application of the Bilan Carbone model to mitigate greenhouse gas emissions in AIT campus. Thailand: Asian Institute of Technology; 2011 [Unpublished master thesis].
[34] Kumar S. Action towards resource-efficient and low carbon cities in Asia project. Energy field of study. Thailand: Asian Institute of Technology. URL: ⟨http://lcc.ait.asia/feature_lcc.php⟩; 2012 [assessed 11.06.12].
[35] Huang IB, Keisler J, Linkov I. Multi-criteria decision analysis in environmental sciences: ten years of application and trends. Science of Total Environment 2012;409:3578–94.
[36] IRIN. Humanitarian news and analysis. United Nations Development Program. Available from: ⟨http://www.irinnews.org/Report.aspx?ReportId=85179⟩; 2012 [assessed 23.06.12].
[37] Siong HC, Ahmad S, M.Z.S.M. Hussein, Wai CL. Low carbon city 2025, Sustainable Iskandar Malaysia. Malaysia: Universiti Technologi Malaysia; 2009.
[38] Price L, Zhou N, Fridley D, Ohshita S, Lu H, Zheng N. Development of a low-carbon indicator system for China. Habitat International 2013;37:4–21 http://dx.doi.org/10.1016/j.habitaint.2011.12.009..
[39] Jiang B, Sun Z, Liu M. China's energy development strategy under the low-carbon economy. Energy 2010;35(11):4257–64.
[40] Luo Z, Tong X. Evaluation on development capability of low-carbon economy and countermeasures in China. Procedia Environmental Sciences 2011;10:902–7.
[41] Hou J, Zhang P, Tian Y, Yuan X, Yang Y. Developing low-carbon economy: actions, challenges and solutions for energy savings in China. Renewable Energy 2011;36(11):3037–42.
[42] Liu L, Liu C, Sun Z. A survey of China's low-carbon application practice—opportunity goes with challenge. Renewable and Sustainable Energy Reviews 2011;15(6):2895–903.
[43] UNIDO—City of Kitakyushu. Seminar for Eco-town Managers, a symposium organized by joint venture of United Nations Industrial Development Organization and City of Kitakyushu, Fukuoka, Japan; 2012.
[44] Limmeechokchai B. Announcement made by the Thai government through electronic media. Thailand: Sirindhorn International Institute of Technology, Thammasat University; 2012.
[45] Maeda T. Reducing waste through the promotion of composting and active involvement of various stakeholders: replicating Surabaya's solid waste management model. Policy Brief no. 9. Japan: Institute of Global Environmental Strategies; 2009.
[46] Leach AM, Galloway JN, Bleeker A, Erisman JW, Kohn R, Kitzes J. A nitrogen footprint model to help consumers understand their role in nitrogen losses to the environment. Environmental Development 2012;1(1):40–66.
[47] Bilgili F. The impact of biomass consumption on CO2 emissions: cointegration analyses with regime shifts. Renewable and Sustainable Energy Reviews 2012;16(7):5349–54.
[48] Pardo Martínez CI, Silveira S. Analysis of energy use and CO_2 emission in service industries: evidence from Sweden. Renewable and Sustainable Energy Reviews 2012;16(7):5285–94.
[49] Ali G, Nitivattananon V. Exercising multidisciplinary approach to assess interrelationship between energy use, carbon emission and land use change in a metropolitan city of Pakistan. Renewable and Sustainable Energy Reviews 2012;16(1):775–86.
[50] Fujikura R, Toyota T. Climate change mitigation and international development cooperation. Routledge: Japan International Cooperation Agency; 2012.